

The Role of Surveying and Mapping in Erosion Management and Control: Case of Omagba Erosion Site, Onitsha Anambra State, Nigeria

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Abstracts

Erosion has been described as the washing away of the top soil as a result of the actions of agents such as water and wind. Gully erosion, being the predominant in Southern Nigeria, is also a type of environmental degradation with a lot of disastrous consequences caused mainly by flood as a result of high precipitation, which is fallout of climate change. It can be determined, especially in terms of extent and scope, monitored and controlled. Surveyors' contributions through provision of the necessary data, which includes, the topographic map of the area, DTM, catchment and watershed information, both centreline and cross sectional profiles of the resultant gully, the plan view of the gully and its tributaries, etc., for the research and design works on erosion control, have been examined. The data provided was also used for the computation of the volume of runoff from the catchment passing through the gully channel as well as the appropriate slope that would reduce the flow speed.

Keywords: Watershed, Catchment, runoff, DTM.

1.0 Introduction

Soil erosion is the detachment of soil particles and it occurs by the action of water, wind and glacial ice as the case may be. Soil erosion may be gradual process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of top soil, which in some cases advance further into gullies of unimaginable magnitude and consequences(figure 8). For instance there were cases in the area of study where it was reported that farmers from a certain community returned from farm a certain day only to realize that their houses have been washed away following a heavy downpour and the flood that resulted from the rain created a deep gully that buried the houses of the farmers, and washed some away.

Generally erosion occurs when raindrops, rainy seasons' runoff, or floodwaters wear away and transport soil particles. It is a complex natural process that has often been accelerated by human activities such as land clearance, agriculture, construction, surface mining, and urbanization.

1.1 Types of Erosion

There are many types of erosion and mentioned here are a few of them, which include: Sheet erosion, Rill erosion, Valley or stream erosion and Gully erosion. Gully erosion, being the main topic of the discus, results where water flows along a linear depression eroding a trench or gully. This is the type that is more predominant in the area of study and it's environ. It is particularly noticeable in the formation of hollow ways where prior to being tarmacked, an old rural road has over many years become significantly lower than the surrounding fields. It usually begins gradually, being initially insignificant, and graduates into an unimaginable monstrous dimension of momentous consequences when ignored. In its developmental stage, it might be in form of a shallow depression following the line of a footpath, but would sooner grow and expand in both depth and bounds into a gruesome gully.

1.1.1 Causes of gully erosion

The likely causative factors of gully erosion could be either natural or anthropogenic sources

Natural factors include:

1. Nature of soil. Some soils have high erodibility factors hence susceptible to high rate of erosion while some soils have very low erodibility factors and as such low rate of erosion.
2. Topography of terrain. Rugged and steep terrains with high slope are more likely to experience high gully erosion rate than flat terrain. This is so because flood, which is an agent of soil erosion increases in velocity with high slope than on flat terrain thereby acquiring greater momentum to move displaced soil particles from one place to another.
3. Amount of precipitation results in high volume of rainfall, which is one of the major factors of gully erosion. The higher the amount of rainfall, the higher the quantity of soil particles that are dissolved, displaced and moved away. High precipitation amounts to high level of flood in most areas. Some areas experience higher precipitation than others.

4. Land cover. Availability of tree canopies and some plants naturally break the effects of direct raindrops on the soil on the one hand and reduce the velocity of flood and its consequences on the soil on the other. Areas without these natural protections, experience high level of erosion and subsequent gullies.

Anthropogenic factors include:

1. Construction projects. Actions carried out both during and after construction such as grading, clearing, and other activities that disturb the surface of the soil, alter existing topography, and remove existing vegetation, can increase erosion potential during construction.
2. Urbanization involving road construction, building development, etc., contribute immensely to gully sites development.
3. Sand excavation. Sand excavation along the sides of the roads by individuals who obtain permission to carry out such excavation contribute to gully developments within the region of study.
4. Quarrying and mining activities. Abandoned pits as a result of mining activities over a long period of time develop into gullies.
5. Increase in the areas covered by pavements and structures and a failure to incorporate into the construction design, control measures that adequately stabilize slopes, re-establish cover on exposed soils, or convey runoffs, can increase erosion long after construction is completed.
6. Poor construction e.g. of roads without adequate provision of drainage to rightly direct the runoffs.
7. Some other causative factors are cattle grazing, deforestation, and bad farming habits of the people and so on.

1.1.2 Effects of erosion

The overbearing effects of erosion on the environment of the host areas cannot be emphasized. Apart from being a major source of land degradation, it has been categorized as one of the major causes of environmental disaster in the state and its environs. One of these effects includes the formation of gullies. As the erosion continues to remove soil along drainage lines, the affected areas continue to deepen. The end results over a long period of years are deep gullies, which continue to enlarge if no measure is taken to check it. The monstrous nature of gullies are such that they continue to enlarge and deepen that some have gone as deep as over 100m and these have resulted in the following

- i. Displacement of communities/settlements. For example some communities in some sections of Anambra State have been displaced by gully erosion. A typical case is that of Umuchiana community near Ekwulobia in Anambra State where the entire community were completely displaced in 2006 due to the expansion of gully sites. a similar case happened in Umuchu community in Njaba area of a neighbouring Imo State. (Igbokwe et al. 2008).
- ii. Destruction of Natural Habitat. Gullies are so devastating that they destroy the natural habitat thereby affecting the flora and fauna in the area.
- iii. Destruction of houses. Cracking of houses and falling of buildings into gully sites are common features in the area. People have lost their investments to gully expansion in areas like Agulu, Nanka, Nnewi, etc., including the study erosion site at Omagba II Onitsha.
- iv. Sedimentation. One of the consequences of gully erosion is the resultant sedimentation. This is because as the soil is being eroded from one area caused by water runoff, it is being deposited in other areas as sediments (Firouzabadi & Davoodi. 2004). This has resulted in the disappearance of some streams and rivers within the zone.
- v. Land Degradation: this is one of the worst environmental problems facing many people worldwide. Over 40million are affected in Nigeria (Uchegbu, 2002). It is the general and gradual reduction of land value mainly as a result of some unhealthy anthropogenic activities on the land. When top soils are washed away by erosion, the soil loses values due to the washing away of soil nutrients by water. Also gullies on their own part create trenches and deep holes that suddenly cut off large portions of lands thereby degrading the values of such lands.
- vi. Damage to Infrastructure. Some infrastructures such as roads and concrete drainages have been broken down and some communities completely cut off.

2.0 Aim and Objectives of the Study

This study is aimed at describing the role of surveying and mapping in the management and control of gully erosion. Attempt to realize this was carried out with the following objectives in mind:

1. To explain how survey method was used for the field data capture.
2. Use of remote sensing technique to acquire and process terrain data
3. Data processing and analysis technique using geo-processing software

3.0 Literature Review/Theoretical Framework

Advancements in geospatial technology, especially developments in both hardware and software components of GIS, remote sensing and field survey equipment have revolutionized the data acquisition, processing, interpretation and presentation methods (Ghilani and Wolf, 2008., Kavanagh, 2006). According to Zinck et al, (2001), remote sensing data offer promising possibilities for identification and monitoring of gullies. While Kheir et al, 2008, also agreed that GIS and remote sensing through the application of its structural classification techniques and decision-tree modelling is very good for erosion risk mapping.

In order to determine the DEM of the erosion catchment in their study, Daba et al, (2003), used the stereo pairs of the digitized aerial photos. Gully boundaries and break lines were measured using DTM and feature collection functionalities. Gully profiles were demarcated by positioning straight lines at regular intervals along the gully length. Then the gully sections were defined as portions of a gully between neighbouring profiles. By applying the relevant software, the gully volume was computed for every gully section. In order to generate topographic parameters and DEM used in the erosion models for computation of soil loss, contour of the topographic maps were digitized and integrated into GIS (Mitasova et al, 1996 and Rinos et al,)

Field survey techniques were also employed in the measurement of gully depths, width and lengths for the computation of volume of soil displaced (Daba et al, 2003)

3.1 The Study Area

New Heritage I and II Omagba phase2 erosion sites as they are called are located towards the north-eastern part of the commercial city of Onitsha in Anambra State south-east Nigeria. Its' geographical location is 6° 09'N and 6° 49'E. The South-East lies within Awka-Orlu uplands and Enugu-Awgu-Okigwe escarpment where gully erosion is a general problem. The sites are situated along Nkpor-Onitsha axis with a high population density hence heavy pressure on the land resources. The area is characterized by high rainfall, highly erodible soils and undulating topography. Muoghalu and Okonkwo (2004) assert that being very close to Awka falls within the Imo shale group. The area is predominantly sandy/clay with sand ranging from 58% to 80% in places. The two erosion sites in the study are within two overlapping catchments with the gully heads expanding and cutting the Enugu-Onitsha express way. One of the sites, the New Heritage II stretches approximately 1400m discharging into Nkisi River, a tributary of the River Niger.

4.0 Materials and Methods

4.1 Materials

For data acquisition the following equipment were used:

1. Dual frequency post-processing GPS 1200 by Leica. Which has Geodetic precision
2. Leica (TPS) 1200 Total Station and its Accessories

Data used are as follows:

1m high resolution Satellite Image from Quickbird was used alongside downloaded ASTER-DEM data from internet. XYZ coordinates data of the gully sites were acquired for cross section and centerline profile, as well as for horizontal alignment/ Plan view

Software used for the data processing are: ArcGIS 9.3 version and Autodesk Land development desktop LDD

4.2 Methods

The project was accomplished from three basic approaches, which are: the field survey data acquisition method, data acquisition through internet and remote sensing, and finally data processing for the final results. Fig 4 is the methods schema

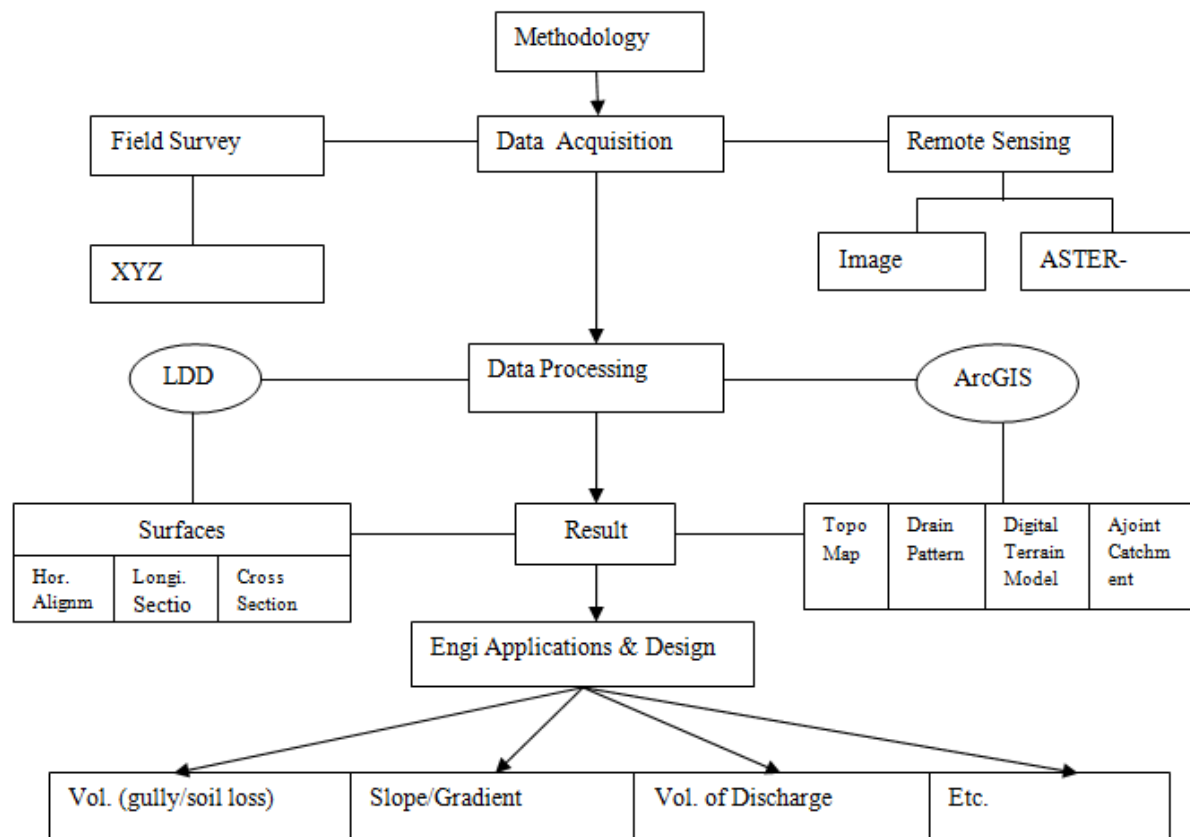


Fig 1. Methodology Schema

4.2.1 Data Acquisition

Data was captured through two major processes. The first method was through direct field survey measurement. Various field survey techniques were applied using the GPS and Total Station to capture the planimetric and height coordinate information in Universal Transverse Mercator system relevant for the gully's horizontal and vertical alignment. Other relevant details for the gully's longitudinal and cross sectional values. Details within 50m buffer to the gullies were also captured using the total station equipment. The second data acquisition technique employed was through the application of remote sensing. High resolution quick bird image was obtained through which further details including features close to the gullies and the gullies plan views were captured by digitizing them. Also topographic information was obtained by downloading the ASTER DEM of the catchment via the internet.

4.2.2 Data processing

The field survey data was processed using the Land development desktop (LDD) by Autodesk. Surface was created using the software from which the longitudinal and cross sectional plans were produced. (See figures 2 & 3). Further processing was carried out on the r/s data using ArcGIS software. The hydrological functions of the spatial analyst tools were used to create TIN for the production of various topographic details and the watershed of the catchment area for analysis.

5.0 Results

The result of the processing are these maps showing the topographic details of the catchment areas of the two erosion sites (New Heritage I and II), at Omagba 2 Onitsha, for watershed analysis and engineering design. Figure 4 shows the image map with highlight on the two erosion sites and some details surrounding them. Figure 5 show the DTM of the erosion catchment formulated from TIN of ASTER-Dem values. It also shows the drainage pattern. Figure 6 shows the ajoint catchment map, while figure 7 is the topographic map of the study area showing the contours and the details including the two erosion sites.

6.0 Discussion

The paper is a technical report of the erosion project carried out by the consultancy unit of the Department of Geoinformatics and Surveying of the University of Nigeria for Anambra state Ministry of Environment under the

counterpart funding arrangement with the World Bank Newmap erosion project. The maps shown in the above figures were as a result of the processed data acquired in the field by a team of surveyors from the institution. These were done in accordance with the job order from the client under the supervision of an erosion engineer. Figure 2 is the longitudinal profile of the gully bed of Omabga II erosion site. This and its corresponding cross section shown in figure 3 were results of the processed ground height data of the gully and are used for the computation of volume of soil eroded as well as for the design of a gentle slope pattern along the flow line. Figure 4 is the image map of the area showing the two erosion sites and the habitats within the catchment. This is used for the environmental and social impact assessment (ESIA) studies. Figure 5 shows the DTM and the drainage pattern achieved using TIN method to process the Aster-dem data of the area. From the drainage pattern, the flow line and potential flood channel can be predicted. Figure 6 shows the contours and the catchment region to the two erosion sites. Lastly is figure 7, which shows the topographic details of the catchment area. It was from this information that the engineer computed the quantity of water discharging into the gully heads. Actually, the supplied information of these processed data was used for various applications by the erosion engineer for design work aimed at determining the following erosion components.

1. Calculation of the volume of the gullies in order to determine the quantity of soil being eroded. This was done using the cross sectional data and the field survey measurements. An agreement exists between the gully depth and the width (Torri and Borselli, 2003).
2. The topographic map of the catchment was used for the calculation of the volume of water flowing into the canal.
3. The flow speed along the canal was obtained by determining the gradient of the flow line. This was done using the longitudinal profile of the gully bed.

7.0 Conclusions

It has been seen from this paper that the roles of Surveyors or the Geomaticians as the case may be in the determination of the fundamental datasets necessary for engineering applications for the planning and design works used for monitoring and control of gully erosion cannot be overemphasized. Through its deployment of modern space technology to capture wide range of data on watershed characterization and analysis, to the utilization of field survey techniques for a more detailed measurement, surveying has been found invaluable as a means of capturing, processing, analyzing and presenting the relevant geo-spatial data necessary for the production of the digital terrain model (DTM), flow direction, drainage pattern, topographic details and the catchment features. Moreover, apart from providing the ground-truthing and more detailed information on gullies, adoption of field survey methods -though might be tedious, provides more job opportunities for surveyors especially in this era where emphasis is on ecological and environmental issues.

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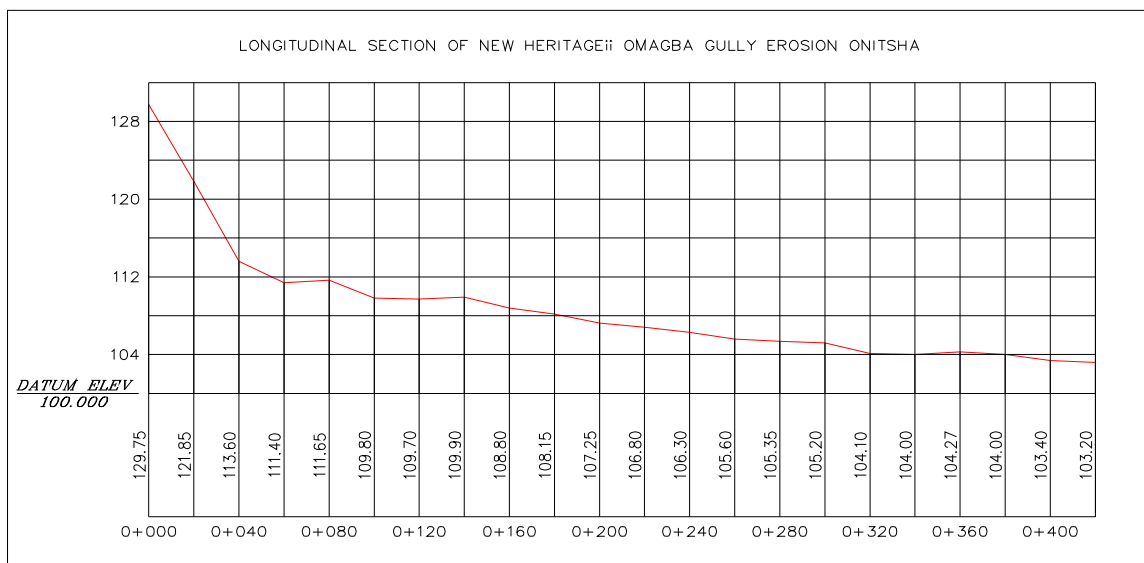


Figure 2 Longitudinal section of the gully bed of New Heritage II erosion site

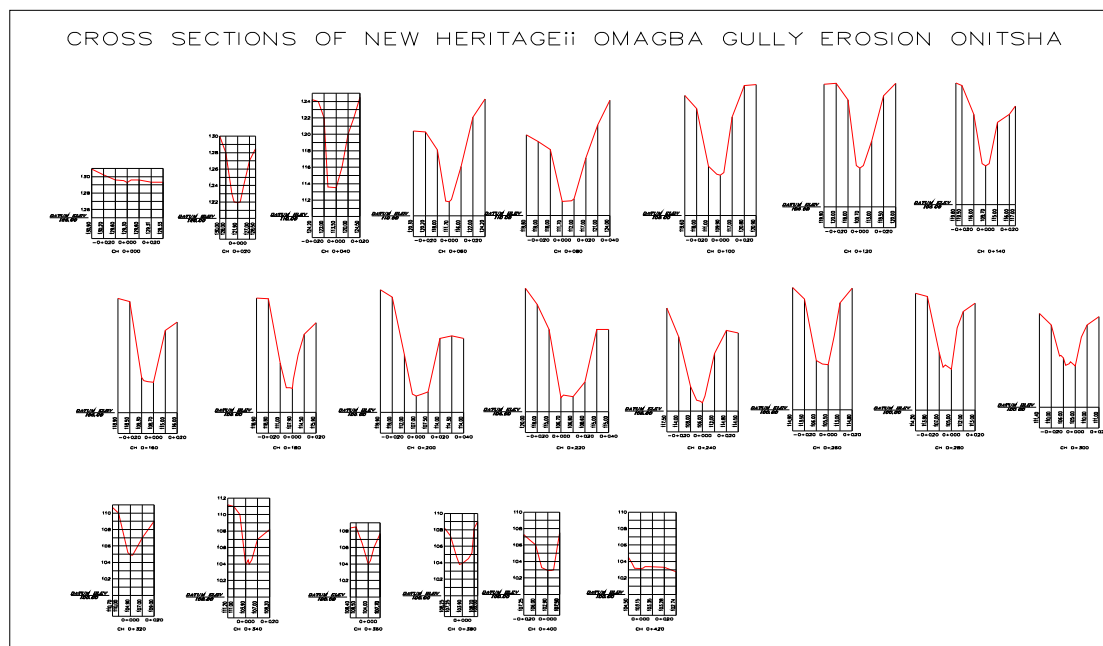


Figure 3 Cross-Sections of New Heritage II Omagba Gully Erosion Site

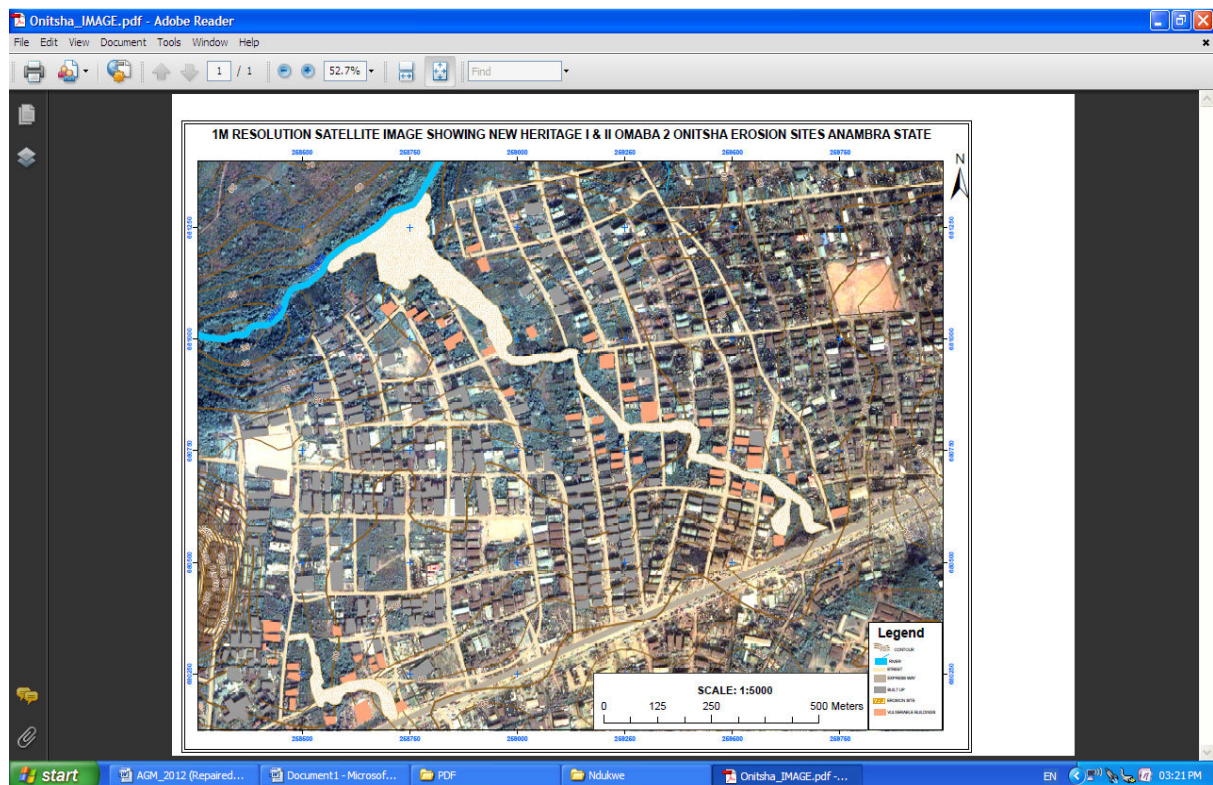


Fig.4 Image map showing in 1m resolution

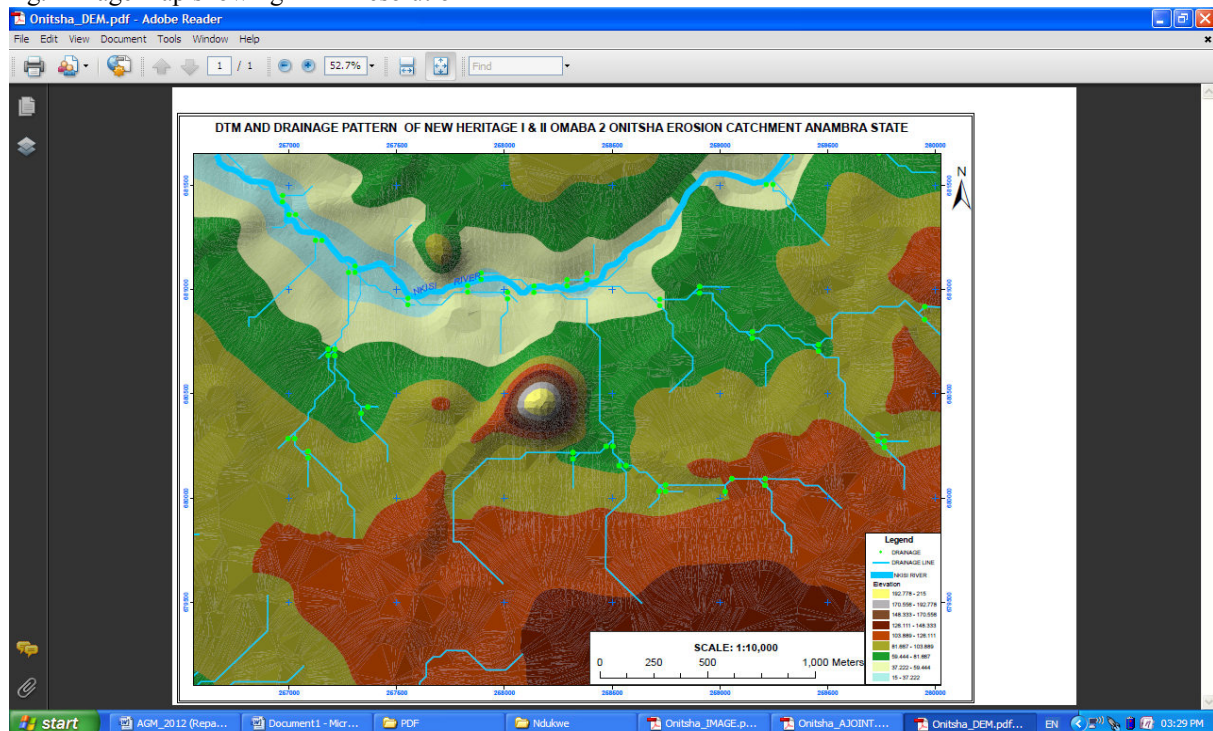


Figure 5. DTM and Drainage Pattern of the sites using TIN

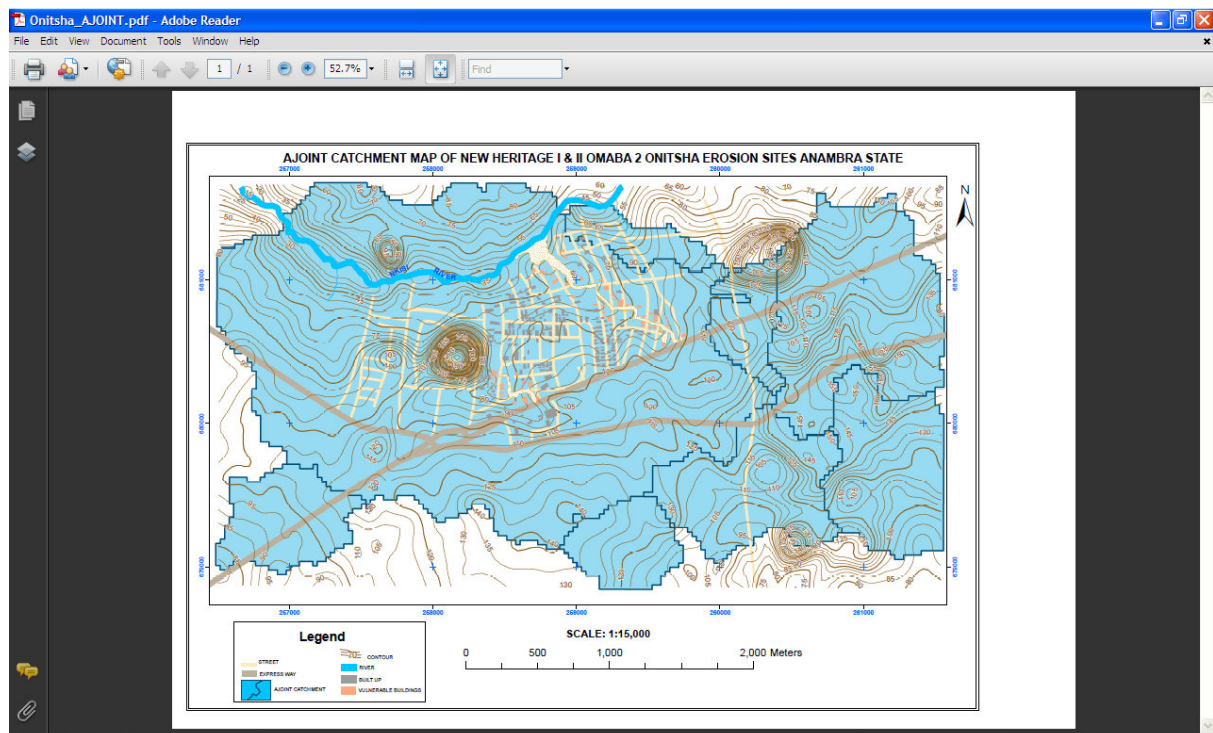


Figure 6 Ajoint Catchment map

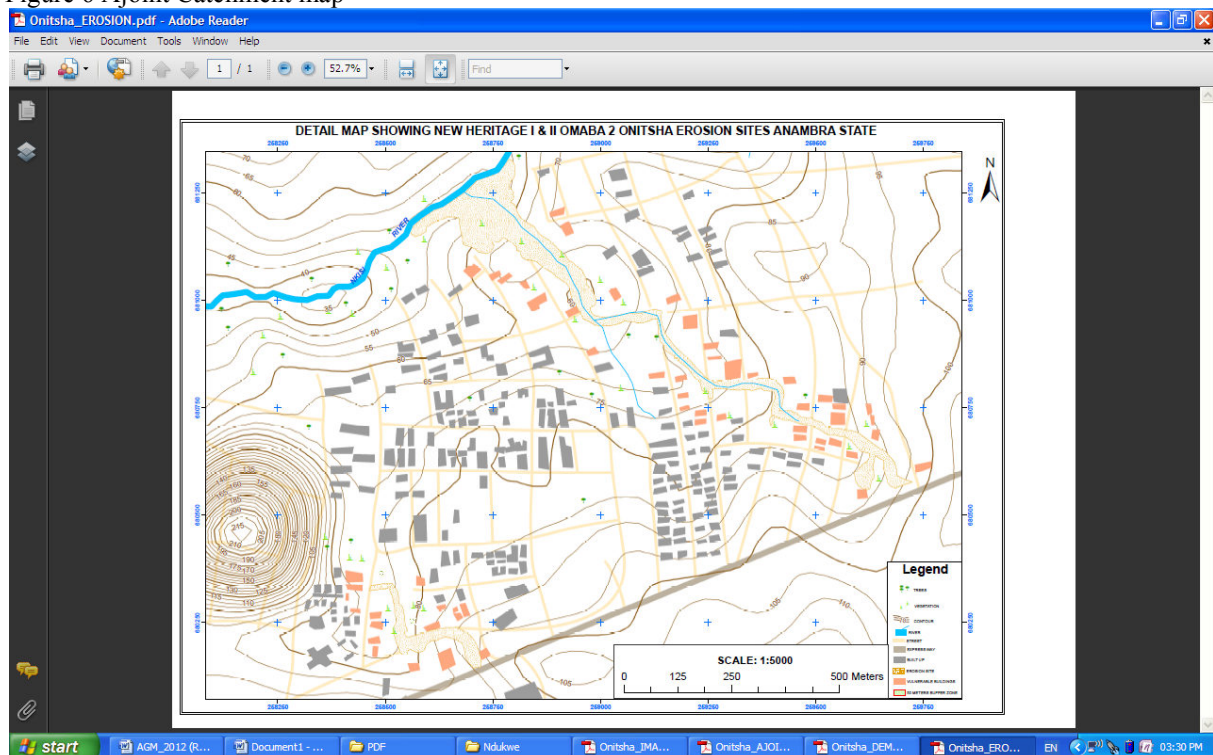


Figure 7 Topographical Map showing details



Figure 8. Omagba Gully site.

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